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COMMERCIAL CONTROL OF CITRUS STEM-END ROT.

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CAUSE OF CITRUS STEM-END ROT.

Stem-end rot of Florida oranges and grapefruit may be caused by either of two fungi, *Phomopsis citri* or *Diplodia natalensis*. The general appearance of the decay is the same in either case. At first there is a slight softening without discoloration over a small area immediately around the stem or button. This soft area enlarges rapidly and by the time it is an inch in diameter assumes a tan or light-brown color. When the main circular area of rot has included about one-third to one-half the surface of the fruit, fingerlike extensions sometimes spread downward in positions corresponding to the divisions between the segments of the pulp, and a small independent rotted area will regularly appear at the point end, the fungus having reached this region quickly by direct growth through the pith tissue of the core. The fruit may be completely rotted in three or four days from the first appearance of the softening if the temperature is favorable for rapid growth of the particular fungus in question.[1]

Both of these stem-end rot fungi flourish and form spores in dead citrus bark. Phomopsis usually develops most abundantly in recently dead bark of very small twigs and fruit stems; Diplodia occurs most frequently on larger twigs and limbs. During periods of warm, rainy weather the spore crops are produced and disseminated. While all the details have not been definitely determined, it seems most probable that first infection involves some portion of the stem button of the fruit some time during the growing season. Under certain unusual seasonal conditions, usually associated with drought and frequently near the time of maturity, stem-end rot may actively affect the fruit in the groves, causing considerable loss from dropping. Ordinarily little or no evidence of stem-end rot is seen until some time after the fruit is picked. The physiological changes following the separation of the fruit from the tree seem to be favorable for the active growth of both of these stem-end rot fungi and for their more or less rapid extension from the button tissues into the fruit proper. The holding temperature plays an important part in determining the rate of rot for a particular lot of fruit and also whether or not the Phomopsis or the Diplodia rot will prevail in cases of double infection. Diplodia develops best at about 85° F. and Phomopsis at about 75° F. Phomopsis can develop slowly in the 50's, but Diplodia is effectively retarded below 55° F.

Experiments for the control of both types of citrus stem-end rot conducted by the Office of Fruit-Disease Investigations of the Bureau of Plant Industry have followed many lines of attack, some of which have proved successful, some unpromising for commercial control, and some entirely ineffective. The following account includes those phases of the work that seem to offer practicable methods of control, with incidental reference to some of the other tested procedures. It is in the nature of a preliminary report for the immediate information of those concerned in the growing and marketing of citrus fruits liable to stem-end rot loss.

PRUNING OUT DEADWOOD.

Theoretically the removal of places of spore production, if thoroughly done, ought to decrease the liability of the fruit to stem-end rot infection. Repeated observations and tests have shown that citrus fruits from comparatively young trees, in which there is relatively little deadwood, do not as a rule develop much stem-end rot in holding tests. Neither is fruit from such trees likely to be severely affected with melanose, a surface blemish also produced by *Phomopsis citri.*

Pruning experiments were conducted in 1921 and in 1922 on fairly well kept large seedling orange trees at Orlando, Fla., to determine the effect of cutting out deadwood on stem-end rot. The work was done as carefully and thoroughly as could be expected on a commercial basis. In 1922 eight plats were pruned once each in every month from April to November, near the 10th of the month. Sample lots of 50 fruits were collected from each plat on three dates—November 16 and 24 and December 22. These fruits were held for 36 days at 70° F. and then for 6 days at 80° F.—a range suitable for the development of blue mold as well as both stem-end rots. At 3-day intervals examination was made for rot, and all fruits showing stem-end rot were cultured to determine accurately whether it was of the Phomopsis or the Diplodia type. Figure 1 shows the average amounts of Diplodia rot and of Phomopsis rot for the eight pruned plats in comparison with the amounts for fruit from unpruned plats.

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[1] *Blue-mold rot.*—Besides the two types of stem-end rot, Penicillium (blue mold, green mold, blister rot) is a common cause of decay. It can develop at lower temperatures than Phomopsis. It may enter at any point where the skin of the fruit is cut or bruised. Its development is very rapid, the primary infections showing as a rule within two or three days after entrance occurs. It requires different procedures for control from the stem-end rots. Briefly, the fruit must be kept free from bruises and scratches of all kinds and from long continuance of surface moisture—from rain or dew, from washing, or from condensation ("sweating")—and it should be held at low temperatures (40° to 45° F.).

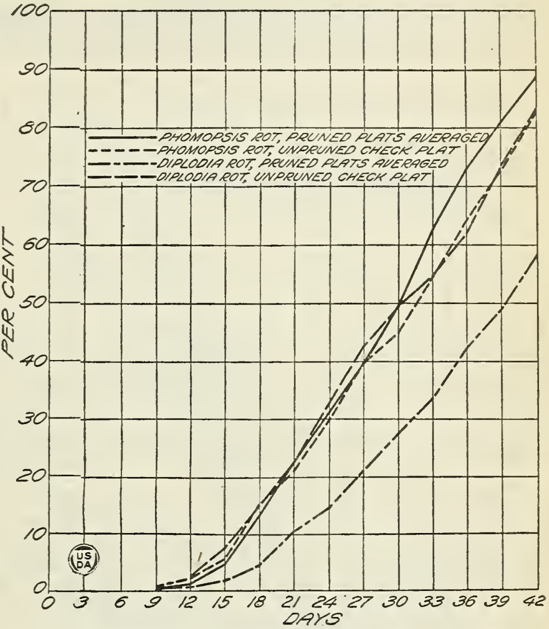

Fig. 1.—Development of Phomopsis rot and Diplodia rot in oranges from pruned plats and from unpruned check plats during the 42 days of the test. The numbers at the left indicate the cumulative percentages of rot, obtained as follows: For each period of 3 days the percentage of Phomopsis or of Diplodia rot is figured on the basis of the number of sound fruits in the test at the beginning of the 3-day period. These percentage figures are added successively to give the cumulative numbers shown. Such numbers represent the proportion of rot that would develop if the test lot were restored to 100 fruits after the removal of the rotten fruits at the beginning of each 3-day period.

It is apparent that pruning has had no definite effect on the amount of Phomopsis rot, but there is a distinct diminution in Diplodia rot, the reduction being about 50 per cent during the first 27 days of the holding. However, it must be borne in mind that at ordinary marketing temperatures Phomopsis would have relatively a greater advantage over Diplodia than at the rather high temperature of 70° F. or higher used in the test. A reduction of 50 per cent in Diplodia rot with no control of Phomopsis rot probably would not make a very great difference in the total rots of Florida fruit in commercial practice. Perhaps the greater effectiveness of pruning against Diplodia rot is due to the fact that Diplodia is found for the most part on larger twigs and limbs that can be rather thoroughly removed. The innumerable small sprigs and fruit stems that regularly harbor Phomopsis can not be removed with thoroughness, and so this kind of infection is not checked. Pruning in every month from April to November reduced Diplodia, but the results were more marked in some months than in others. Further tests must be made before it can be determined whether any particular time of year will prove to be consistently the best for such pruning work.

On the whole it would seem that pruning out deadwood alone can not be depended upon satisfactorily to control citrus stem-end rot, at least where Phomopsis prevails. When carefully done it may materially reduce Diplodia rot.

SPRAYING FOR STEM-END ROT CONTROL.

Spraying experiments followed by holding tests on the fruits during the past three years have indicated that applications of copper sprays that will control melanose on the young fruits will also in large measure reduce Phomopsis stem-end rot, but spraying later than about the first week in June is not effective for rot of this type. Up to the present time it does not seem possible to control Diplodia stem-end rot by an economically practicable spraying schedule. Figures 2 and 3 show results obtained on selected plats from the 1922 spraying experiments, which bear out the above general conclusions. The sprayed trees were old unpruned seedling orange trees with a large amount of deadwood. The spray material was 3–3–50 Bordeaux mixture plus 1 per cent oil as emulsion. The plats shown in Figures 2 and 3 were sprayed on the following dates:

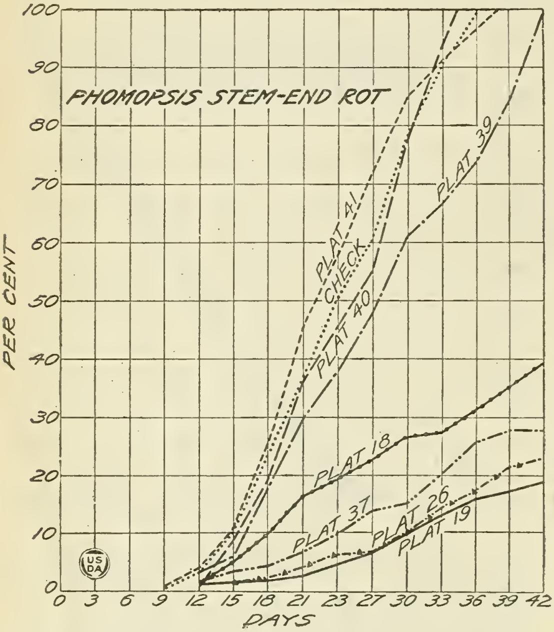

Fig. 2.—Development of Phomopsis rot in oranges from plats sprayed at various times with 3–3–50–1 Bordeaux-oil emulsion and from unsprayed check plats during the 42 days of the test. The numbers at the left indicate the cumulative percentages of rot, obtained as follows: For each period of 3 days the percentage of Phomopsis rot is figured on the basis of the number of sound fruits in the test at the beginning of the 3-day period. These percentage figures are added successively to give the cumulative numbers shown. Such numbers represent the proportion of rot that would develop if the test lot were restored to 100 fruits after the removal of the rotted fruits at the beginning of each 3-day period.

Plat 18, on April 10; plat 19, on April 10, May 1; plat 26, on April 12, May 10; plat 37, on April 12, May 11, June 10, July 10, August 10, September 10, October 10; plat 39, on June 10, July 10, August 10; plat 40, on July 10, August 10, September 10; plat 41, on June 10, July 10, August 10, September 10, October 10; plat 50, unsprayed check.

It would seem that two applications, one early in April, the other early in May, give the best control of Phomopsis rot, although one application made on April 10 reduced this rot materially. Spraying seems to have some slight effect in reducing Diplodia stem-end rot, but not enough for its practical control.

Any spraying that will prove effective for melanose control[2] would be expected to have additional effect in controlling the Phomopsis type of stem-end rot.

REMOVAL OF STEM "BUTTONS."

Extensive experimental evidence indicates strongly that both Phomopsis and Diplodia first gain a foothold somewhere on the stem or button of the fruit and later grow through the stem cushion into the fruit proper. Removal of the stems before this extension into the fruit ought to prevent stem-end rot. Early tests in pulling the fruit from the trees showed that stem-end rot was very much reduced, but increase in blue-mold rot following the tearing of fruit tissues incident to the pulling offsets the saving from the stem-end rot. The gassing method for coloring citrus fruit, recently widely adopted in Florida as a result of investigations by the Office of Horticultural and Pomological Investigations of the Bureau of Plant Industry, often causes considerable shedding of buttons, which has been considered an objectionable feature. This suggested that gassing might be utilized for control of stem-end rot because of its loosening effect on the buttons. The results of extensive tests have been highly satisfactory, and it is believed that this process affords a comparatively simple and very effective means of controlling both types of stem-end rot and of greatly prolonging the life expectancy

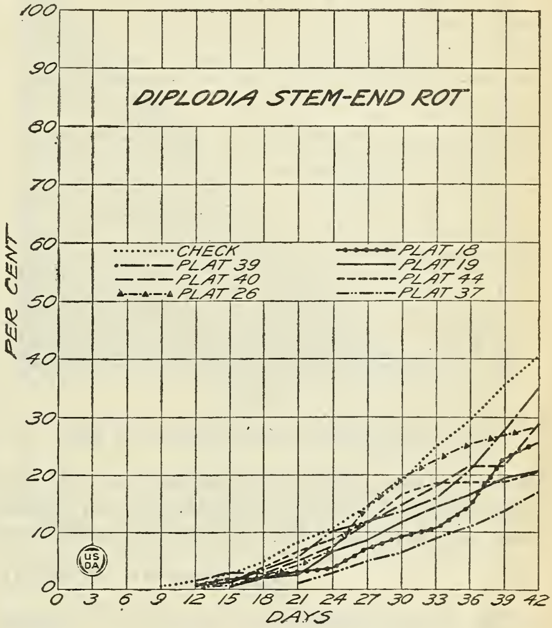

FIG. 3.—Development of Diplodia rot in oranges from plats sprayed at various times with 3–3–50–1 Bordeaux-oil emulsion and from unsprayed check plats during the 42 days of the test. The numbers at the left indicate the cumulative percentages of rot, obtained as follows: For each period of 3 days the percentage of Diplodia rot is figured on the basis of the number of sound fruits in the test at the beginning of the 3-day period. These percentage figures are added successively to give the cumulative numbers shown. Such numbers represent the proportion of rot that would develop if the test lot were restored to 100 fruits after the removal of the rotted fruits at the beginning of each 3-day period.

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[2] Winston, John R., and Bowman, John J. Commercial control of citrus melanose. U. S. Dept. Agr. Dept. Cir. 259, 8 p. 1923.

of fruit otherwise liable to loss from stem-end decay. Figures 4, 5, and 6 show combined results from 19 tests with samples of 50 oranges each, conducted during the season of 1922–23. The fruit was taken from old trees with much deadwood and was more subject than the average to stem-end rots. The disbuttoning occurred at various times from 2 to 6 days after the fruit was picked. After treatment, the fruit was held for 36 days at 70° F. and for 6 more days at 80° F., and the test was consequently very severe on the keeping quality. The tests show the effects on the various rots of gassing with stem removal as compared with gassing without stem removal and with untreated fruits. For the first 30 days of the holding tests stem-end rot is almost a negligible factor in the disbuttoned fruit. Under ordinary commercial conditions of lower temperatures the losses from stem-end rot in such treated fruit ought to be even less. Gassed fruit with buttons left in place kept hardly as well as untreated fruit.

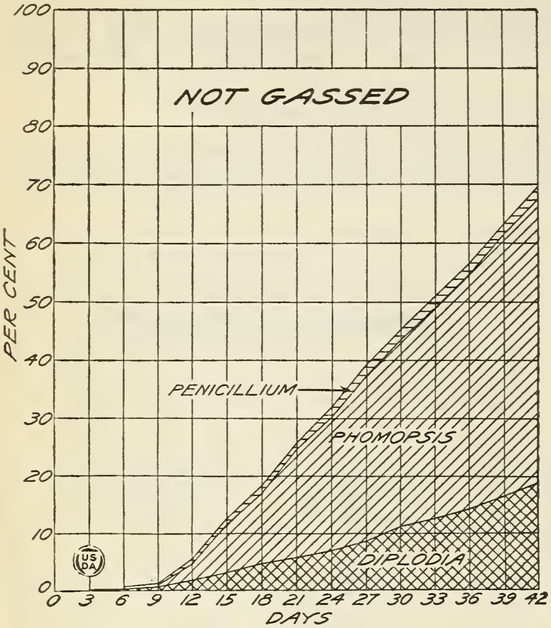

FIG. 4.—Proportions of various rots per 100 oranges originally in the test, not gassed, held for 42 days.

METHOD OF GASSING.[3]

The most satisfactory method to follow in gassing[4] fruit to improve its color and at the same time to loosen the buttons is to subject the fruit for about 36 hours to gas from a gasoline engine exhaust or from a kerosene-oil stove with imperfect combustion, holding the coloring room at a temperature ranging from 80° to 85° F. with the humidity between 85 and 90 per cent. Sweating must be avoided to prevent blue-mold decay. Such a combination of factors causes the buttons to loosen and to be easily rubbed off by the brushes and polishers. The color develops and the buttons loosen simultaneously, hence there is no appreciable increase in the time that the fruit has to be subjected to the above conditions to obtain both results. Ordinarily the cost of this process is not more than 1 cent per box.

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[3] General information about the construction and operation of coloring plants for Satsuma oranges is contained in United States Department of Agriculture Bulletin No. 1159, "Coloring Satsuma oranges in Alabama," by R. C. Wright. Detailed information on the gassing process for coloring citrus fruits, as adapted to Florida conditions, may be obtained from the Bureau of Plant Industry, Department of Agriculture, Washington, D. C.

[4] Practically all of the technique involved in coloring and at the same time disbuttoning citrus fruits has been evolved by W. R. Barger, of the Office of Horticultural and Pomological Investigations, who has also rendered valuable assistance in conducting the tests mentioned above.

HOLDING AT LOW TEMPERATURES.

Figure 7 shows the development of the two kinds of stem-end rot when fruit is held at various temperatures ranging from 10° to 30° C. (50° to 86° F.). It will be noted that the amount of rot to be expected at any length of time from picking, or the time required to develop any given percentage of rot, depends on the holding temperature. Phomopsis in general ranges about 5 degrees C. (9 degrees F.) below Diplodia in its limits of activity. It is evident that loss from both types of stem-end rots may be avoided for a reasonable marketing period if temperatures are kept low enough, probably not more than 45° F. for Phomopsis or 55° F. for Diplodia. The sooner the fruit is subjected to the low temperature and the quicker the interior of each fruit reaches such temperature the better the results. Precooling seems to accomplish this end effectively.[5]

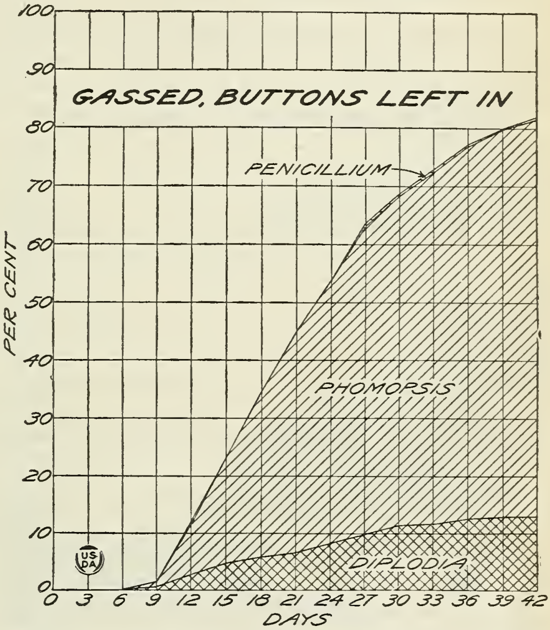

FIG. 5.—Proportions of various rots per 100 oranges originally in the test, gassed and buttons left in, held for 42 days.

QUICK MARKETING.

If holding temperatures are not kept low and if the potentially infected fruit is not otherwise protected from stem-end rot decay, it is of the utmost importance that it be consumed before the inevitable loss occurs. Delay in packing, too long hauls to distant markets, delays in transit, and overstocking by dealers should be avoided in so far as may be possible. A peculiarity of both types of stem-end rot is that development of rot is long drawn out in any lot of fruit. A particular fruit may be entirely sound for many weeks and then overnight develop the first symptoms of stem-end rot. Such fruits are all right until rot sets in, but are worthless afterwards. Whatever can be done to shorten the average time from the tree to the consumer will lessen by so much the aggregate loss from stem-end rot.

OTHER PROCEDURES TESTED.

It might be supposed that clippers would become more or less contaminated with Phomopsis or Diplodia spores and the cut surfaces of the stems become infected through this agency. Tests have shown that when clippers are contaminated heavily in experimental trials stem-end rot is increased following their use, but numerous tests on clippers in active use in the ordinary way have failed to show any gain through disinfection of them between cuts.

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[5] Ramsey, H. J. Handling and shipping citrus fruits in the Gulf States. U. S. Dept. Agr., Farmers' Bul. 696, 28 p., 10 figs. 1915.

On the hypothesis that the small portion of stem which is left when the fruit is clipped becomes infected after picking, particularly by Diplodia, it has been held[6] that shellacking the stem end will reduce this rot, this treatment being most effective when the fruit is pulled rather than clipped. The writers have tried this method repeatedly under Florida conditions with and without disinfection previous to shellacking. If the stems are left, the method does not control stem-end rot; if the stems are properly removed, the treatment is unnecessary.

Chemical disinfection in the soaking tank has not been effective.

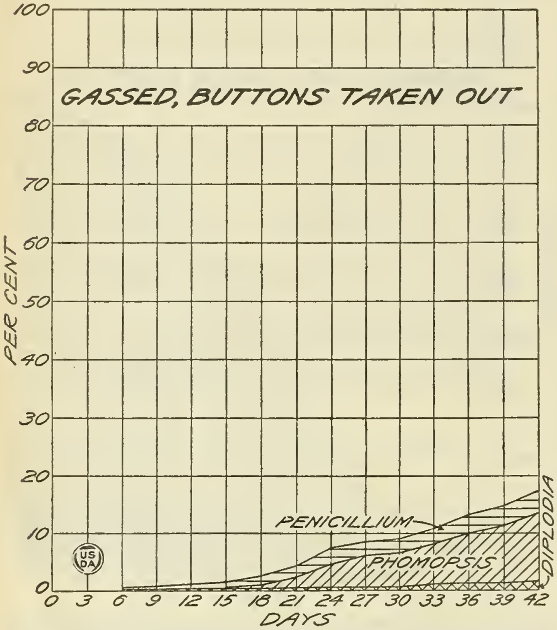

FIG. 6.—Proportions of various rots per 100 oranges originally in the test, gassed and buttons removed, held for 42 days.

GENERAL RECOMMENDATIONS FOR CONTROL.

It has been seen that the control of the two citrus stem-end rots is a complex proposition for which many people share the responsibility.

The grower, as a matter of good grove practice, should keep his trees reasonably free from deadwood, but it is not practicable by this method alone to control stem-end rot. It has little or no effect on Phomopsis rot and reduces Diplodia about one-half. The cost of securing this reduction will be excessive in comparison with other control measurs if the expense of deadwood removal is chargeable to this alone; where the pruning is necessary as a result of storm or cold injury the improvement in the keeping quality of the fruit may be reckoned as an additional gain. Spraying for melanose control (one or two applications of 3–3–50–1 Bordeaux-oil emulsion between April 5 and May 5) will greatly prolong the keeping quality of the fruit through marked reduction of Phomopsis rot, but it will have only slight effect on Diplodia. In the light of our present knowledge it is doubtful whether the grower, in order to control stem-end rot by spraying, would be justified in going beyond melanose-control requirements. He may count such control as an added inducement to undertake spraying for melanose or as justification for two spray applications rather than one.

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[6] Rogers, John M., and Earle, F. S. A simple and effective method of protecting citrus fruits against stem-end rot. *In* Phytopathology, v. 7, pp. 361–367, 1917.

The packer will have the responsibility of deciding whether or not gassing for button removal shall be carried out on any particular lot of fruit. The evidence now indicates that fruit most subject to stem-end rot can be transformed into the very best keeping sort by disbuttoning, and that slightly infected fruit will thus be materially improved in keeping quality. If the fruit comes from young uninfected trees or has had effective melanose spraying, disbuttoning may be less necessary, particularly if the fruit is marketed quickly. The packer must see to it that the fruit is handled with the least possible delay and kept as cool as possible. He is responsible for precooling the fruit when advisable.

The carrier is responsible for transporting without unusual or unnecessary delay and for proper attention to temperature and ventilation requirements in transit.

The dealer should try to speed up the prompt movement of citrus stock and especially should avoid keeping stock subject to stem-end rot on hand for long periods. He should hold it at temperatures low enough to effectively retard stem-end rot.

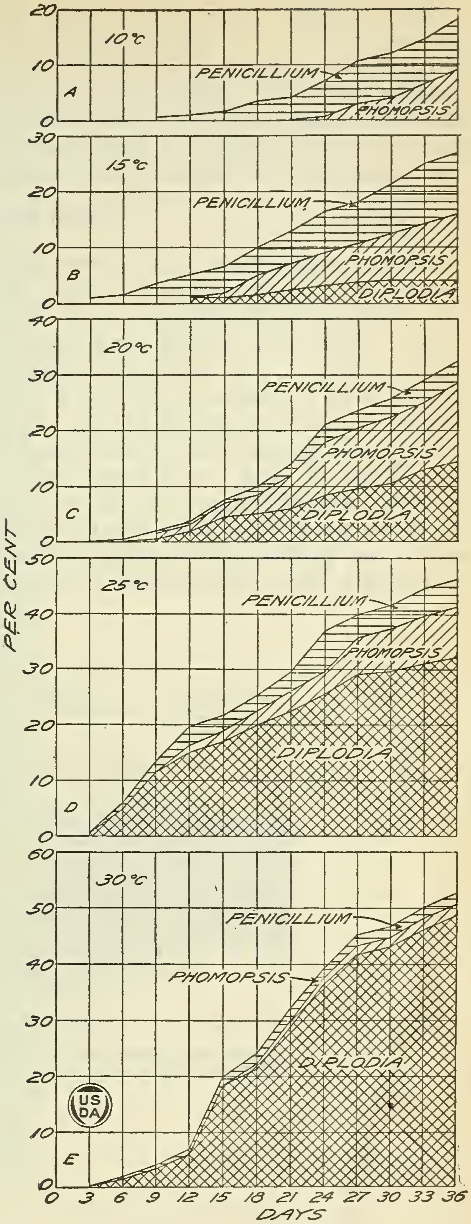

FIG. 7.—Proportions of various rots per 100 oranges originally in the test, held for a period of 36 days at the following temperatures: *A*, at 10° C. (50° F.); *B*, at 15° C. (59° F.); *C*, at 20° C. (68° F.); *D*, at 25° C. (77° F.); *E*, at 30° C. (86° F.)

The consumer also has certain responsibilities regarding stem-end rot. While for many reasons it may be desirable to purchase citrus fruit in quantity, as in original boxes, this involves risk when dealing with fruit subject to stem-end rot. Large retail purchases should be made only after reasonable assurance about their expected keeping quality, and the fruit should be held whenever possible at the temperature of a good refrigerator until used.

SUMMARY.

Briefly summarized, the following measures are recommended for control of stem-end rot in oranges and grapefruit: Prune the trees for removal of deadwood, in so far as good orchard practice requires. Spray the young fruit once or twice with 3–3–50 Bordeaux mixture plus 1 per cent oil as emulsion during April or certainly before May 5 (under ordinary Florida conditions), as may be required for good melanose control. If the fruit comes from old trees with much deadwood, disbuttoning by gassing should be resorted to. Even if such trees have been pruned and the young fruit sprayed, disbuttoning will add to its keeping quality through more complete protection from stem-end rot. Keep the fruit at low temperatures, preferably between 40° and 45° F., and shorten as much as possible the time between picking and ultimate consumption.

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